EMPIRICAL RESEARCH PRESS

International Journal of Engineering and Applied Computer Science

Volume: 04, Issue: 04, May 2022 ISBN: 9780995707545

Prototype for Multimedia Content Delivery based on Non-Transmittable Codewords Enhanced Viterbi Algorithm

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10.24032/IJEACS/0404/010

Empirical Research Press Ltd.

London, United Kingdom

www.ijeacs.com

Volume: 04, Issue: 04, ISBN: 9780995707545, May 2022

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***Abstract*—The paper provides a prototype for multimedia content delivery with reduced channel code rate from conventional Non-Transmittable Codewords Enhanced Viterbi Algorithm. The code rate reduction was simulated using VB.NET Viterbi simulator available at College of Informatics and Virtual Education-University of Dodoma. The study approximates Uplink and downlink speeds limits of the prototype using High Speed Packet Access Evolved technology by assuming all other parameters remain constant. The uplink and downlink of the prototype is clearly presented. The code rate of 1/3 was obtained by simulating different 8-bits patterns. This code rate of 1/3 enabled reduction of encoder output bits from 48-bits to 24-bits, therefore, few bits would be sent to the network and bandwidth conservation is attained. This makes the prototype to be the good choice for low network bandwidth channel. In addition, the reduced code rate will reduce the expenses of user internet bundles, because number of MBs to be charged will be smaller. This prototype for multimedia delivery over network has three benefits, high data transmission reliability due to adopted NTC Enhanced Viterbi, minimum network bandwidth utilization and satisfied uplink and downlink access speed.**

Keywords- Non-Transimmitable Codewords, Viterbi, Coding, Code Rate.

I. INTRODUCTION

Forward Error Corrections (FEC) since 1940s, is one of classes of techniques used for reliable data transmission at the price of bandwidth expansion ([3], [4]). This bandwidth expansion is due to the fact that, FEC encoder adds additional bits per one or more original bits of data in order to compact introduced transmission errors ([5], [6]). These additional bits are called redundancy bits, and they are used by techniques implemented at decoder to recover original data bits even if some bits were received in errors [7].

One of famous algorithms that have been used to recover data bits at the decoder is called Viterbi Algorithm (VA) ([8], [20]). VA works with code rate of 1/ 2, meaning 1-bit of data at encoder will produce 2-bits for transmission, and the VA will restore that bit from received 2-bits. Hence for Forward Error Corrections (FEC) schemes, the degree of reliability and the corresponding redundancy depend on code rate of particular FEC algorithm and encoder implemented.

Innovation of high-speed technologies i.e., 3G to 5G technologies, urbanization and unsettled environmental conditions make VA to poorly recovery transmitted data bits at destination, especially when there is burst error conditions ([9], [20]). The burst errors make VA to left many numbers of bits in errors, therefore, data are retrieved in distorted state. These remains errors are called residual errors ([10], [11]).

Non-Transmittable Codewords (NTC) Enhanced Viterbi Algorithm (VA) reported in ([12], [19]) has improved VA in term of residual error corrections by more than 80%. The NTC Enhanced VA achieved these results, by using two techniques called Lower Locked Bits (LLB) and Non-Transmittable Codewords. The overall code rate of this NTC Enhanced Viterbi is 1/6; meaning for 1-bit of data encoder will produce 6-bits for transmission.

The term Multimedia, is used when there is integration of digital medias i.e., text, images and video, in a single telecommunication service [1]. Multimedia content being in digital format, takes advantage of all digital processing including encryption, compression and encoding.

Multimedia files have large number of megabytes [27]. Explosion of multimedia applications such as WhatsApp and YouTube would results to traffics that can flood the network. The outcome will be demands of large network bandwidth, high data transmission reliability and the needs of a low transmission delay from the network [28]. Failure to meet those demands would cost in time - delay sensitive feature of multimedia. Due to high channel coding rate of 1/6 for NTC Enhanced VA [12], then network transmission of multimedia files under NTC Enhanced will demands large buffer size at network nodes and large network bandwidth for transmissions.

During network-busy hours, the code rate employed in NTC enhanced method can overwhelm existing technologies channel capacities (refer Figure 1), because bits streams of large multimedia files demand large transmission bitrates. Hence, networks with lower transmission bitrates will experience high network latency and data transmission delay.

This paper therefore, developed a prototype based on Non-Transmittable Codewords Enhanced Viterbi Algorithm with reduced code rate from 1/6 to 1/x, where x<6 so as to conserve network bandwidth. The paper also approximates the prototype uplink and downlink transmission speed limits, for multimedia content delivery.

II. METHODOLOGY

The study involved two procedures, 1st is a simulation of encoder outputs bits in order to determined reduce code rate, and 2nd consist of approximations of the uplink and downlink speeds bounds. Both 1st and 2nd results were used to design the uplink and downlink of the prototype.

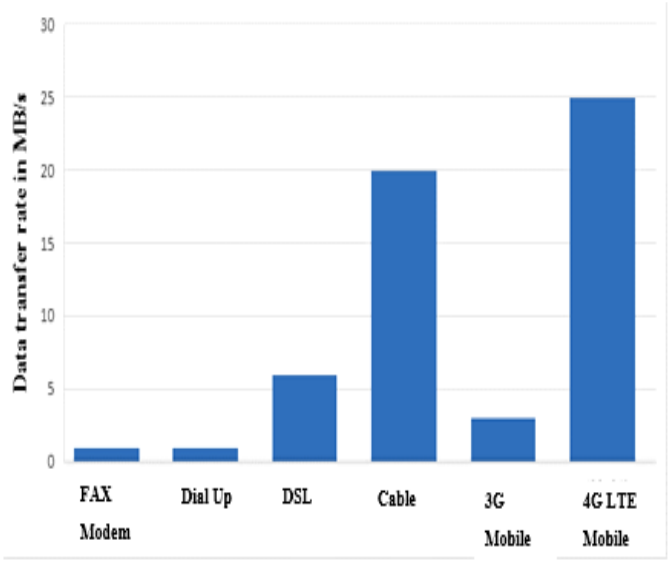

Figure 1. Channel capacities of technologies supporting multimedia delivery [14]

A. Simulation

VB.NET Viterbi simulator available at University of Dodoma was used for the simulation. The simulator was used to generate randomly 8-bits patterns as input to the encoder. These patterns were passed to the simulator (2, 1, 2) lower locked convolutional encoder to generates 48-bits pattern for transmissions. To simulate effect of transmission media, random numbers of bits were deleted from transmitted bits patterns. The modified patterns submitted to the NTC enhanced decoder, and a measurement against bit recovery ability was conducted.

The study variables at this simulation were number of deleted bits at encoder outputs in relation to bit recovery performances. The bit recovery performance was given as 1-BER, where BER stand for Bit Error Rates, expressed as ratio of number of bits in error over original number of bits. In this study, this BER corresponding to the ratio between number of bits in error of the recovered 8-bits pattern from the simulator after certain encoder output bits' deletion against original 8-bits pattern. The simulation results are plotted in Figure 2.

B. Speed Approximation

High Speed Packet Access Evolved (HSPA+) is the 3G technology with at least better performance for multimedia applications, when installation of 4G or later technologies is expensive ([2], [16]). HSPA+ implement hybrid Automatic Repeat Request (HARQ), whereby convolutional codes are used in transmission of small block size of data i.e., Broadcast Control Channel (BCH) data. A theoretical assumption made for the HSPA+ in validating the study is such that, all other parameters of HSPA+ are remain constant, and only code rate and speeds are mutable. The term code rate stands to signify number of bits taken by encoder and number of bits that will be produced.

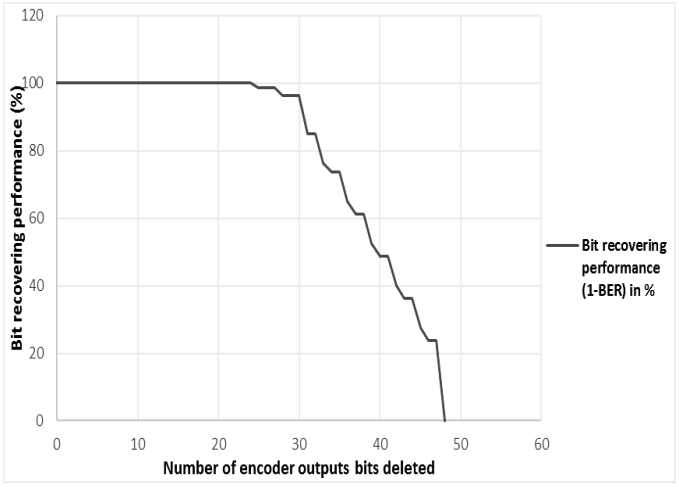

Figure 2. Bit recovery performance in percentage (%) against Number of encoder outputs bits deleted

The uplink and downlink throughput specifications for HSPA+ access network is given in Table I and Table II. The cat 27, cat 28 were selected for downlink comparisons, because they offer Multiple Input and Multiple Output (MIMO). MIMO allows aggregated transmission bitrate to be high ([13], [29]). The cat 9 was selected for uplink comparisons, because it has high order modulation scheme, a 16-Quadrature Amplitude Modulation (16QAM) which allow 4-bits per symbol, therefore high bitrate [25].

Boyle's law ($V_1P_1 = V_2P_2$, where V= Volume and P= pressure) was adopted as mathematical comparison formula. The formula has been explained in [22] that, it can be used for comparing the same substance under two different sets of condition, therefore, the formula was modified to:

$$\text{New Peak rate } (R_n) = \frac{\text{HSPA Peak rate (Ro) x NTC code rate}}{HSPAcoderate} . \quad (1)$$

TABLE I. HSPA+ UPLINK THROUGHPUT SPECIFICATION [15]

Cat	Modulation	Code rate	speed (Peak rate)	3GPP Release
8	QPSK	1/1	11.50Mbps	9
9	16QAM	1/1	23.0Mbps	9

TABLE II. HSPA+ DOWNLINK THROUGHPUT SPECIFICATION [15]

Cat	Modulation	MIMO	Code rate	Speed	Rel.
21	16QAM	-	5/6	23.4Mbps	8
22	16QAM	-	1/1	28.0Mbps	8
23	64QAM	-	5/6	35.3Mbps	8
24	64QAM	-	1/1	42.2Mbps	8
25	16QAM	Yes	5/6	46.8Mbps	9
26	16QAM	Yes	1/1	56.0Mbps	9
27	64QAM	Yes	5/6	70.6Mbps	9
28	64QAM	Yes	1/1	84.4Mbps	9

1) ***Uplink Speed Approximation:*** In the case of uplink, the cat 9 release 9 was selected, whereby, Ro = 23.0 Mbps and HSPA has Code rate = 1/1 as shown in Table III.

   a) ***Case 1:*** NTC code rate = 1/ 6, Ro = 23.0 HSPA Code rate = 1/1 from formula 1, New Peak rate (R_n) = 3.83 Mbps.

   b) ***Case 2:*** NTC code rate = 1/ 3, Ro = 23.0 HSPA Code rate = 1/1 New Peak rate (R_n) = 7.67 Mbps.

TABLE III. UPLINK CHANNEL BANDWIDTH SPEED APPROXIMATION

	Peak rate	Code rate
HSPA+	23.0 Mbps	1/1
Existing NTC Viterbi Algorithm	3.83 Mbps	1/6
Prototyped NTC Viterbi Algorithm	7.67 Mbps	1/3

2) ***Downlink Speed Approximation:*** In this part, there were two cases; case 1 for, cat 27 release 9, Ro = 70.6 Mbps, HSPA Code rate = 5/6 and case 2 for, cat 28 same releases, Ro = 84.4 Mbps, HSPA Code rate = 1/1 as shown in Table IV.

   a) ***Case 1:*** NTC code rate = 1/ 6, Ro = 70.6, HSPA Code rate = 5/6 from formula 1, New Peak rate (R_n) = 14.12 Mbps and for NTC code rate = 1/ 3, Ro = 70.6, HSPA Code rate = 5/6, New Peak rate (R_n) = 28.24 Mbps.

   b) ***Case 2:*** NTC code rate = 1/ 6, Ro = 84.4, HSPA Code rate = 1/1, New Peak rate (R_n) = 14.06 Mbps and for NTC code rate = 1/ 3, Ro = 84.4, HSPA Code rate = 1/1, New Peak rate (R_n) = 28.13 Mbps.

TABLE IV. DOWNLINK CHANNEL BANDWIDTH SPEED APPROXIMATION

		Peak rate	Code rate
HSPA+	Cat 27	70.6 Mbps	5/6
	Cat 28	84.4 Mbps	
Existing NTC Viterbi Algorithm	Cat 27	14.06 Mbps	1/6
	Cat 28	14.12 Mbps	
Prototyped NTC Viterbi Algorithm	Cat 27	28.13 Mbps	1/3
	Cat 28	28.24 Mbps	

III. RESULTS AND DISCUSSIONS

This part deliberates results obtained the study experiments. Results from study simulations and theoretical speed approximations are delivered. The uplink and downlink of the prototype are presented in this part.

A. Simulation Observation

Figure 2 shows that, average maximum number of bits' deletion that gives bit recovery performance of 100% is 24, this implies, 24-bits can be deleted without introducing errors during retrieval of message at destination. The Figure 2 also shows that further deletion from 24-bits, bit recovery performance starts to degrade. The 24-bits deletion threshold makes code rate to be 1/3 from 1/6 i.e., only 24-bits can be transmitted out of 48-bits.

B. Speed Results Discussions

From Table III, the prototype increases the uplink channel speed of existing NTC Enhanced Viterbi by 20%. The prototype uplink speed obtained was 7.67Mbps, which has nearly cat 8 release 9 theoretical speed capacity, which is 11.50 Mbps under QPSK. Although the speed is still lower than that of cat 8 release 9, the uses of 16QAM enable more bits per symbol, which reduced symbol rate in comparison to QPSK; therefore, uplink of the prototype still provides profitable speed for multimedia content delivery.

From Table IV, the downlink speed of HSPA+ - cat 27 and cat 28 were used for approximation; in both cases the prototype shows improvement of 10% against conventional code rate. The study selected cat 28 in its implementation. This is because it provides a higher downlink speed than that of cat 27 of HSPA+. When referenced from cat 28, the prototype downlink speed was 28.24Mbps, while existing NTC Enhanced Viterbi was 14.12Mbps; therefore 10% improvement was obtained.

In assessment to HSPA+ technology, the prototype speed is above 28.0Mbps of the HSPA+ cat 22 release 8. The HSPA+ cat 22 release 8 has no Multiple Input Multiple Output (MIMO) while the prototype uses MIMO. The suggestion of using MIMO to the prototype can boost speed capacity to nearly 35.3Mbps of HSPA+ cat 23 releases 8 in physical implementation.

C. The Uplink and Downlink of the Prototype

Figures 3 and 4 below provide uplink and downlink of the prototype based on NTC enhanced VA, which was designed based on results discussions of this paper. The high compression algorithm or tools are suggested at source coding so as to minimize number of bytes would be sent to the encoder of the prototype; therefore, few bits will be processed.

1) Uplink of the Prototype:

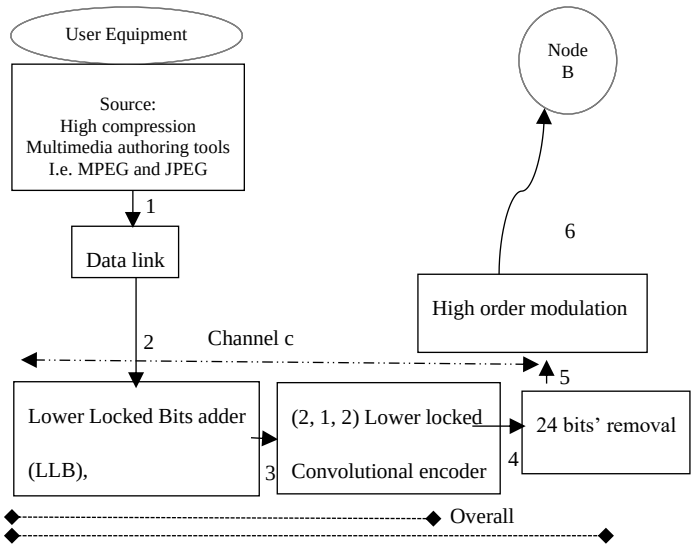

Figure 3. Uplink of the prototype

2) Downlink of the Prototype:

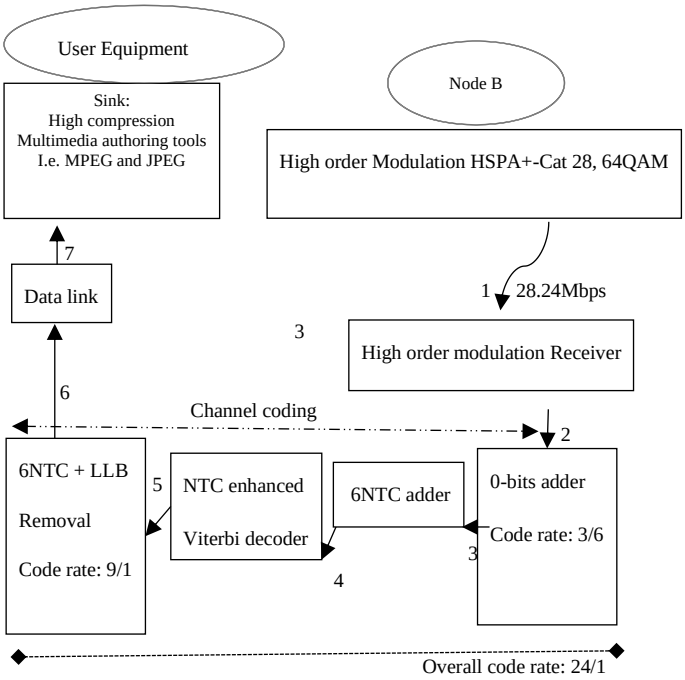

Figure 4. Downlink of the prototype

IV. CONCLUSION

The code rate of 1/3 was obtained by simulating different 8-bits patterns. This code rate of 1/3 enabled reduction of encoder output bits from 48-bits to 24-bits, therefore, few bits would be sent to the network and bandwidth conservation is attained. This makes the prototype to be the good choice for low network bandwidth channel. In addition, the reduced code rate will reduce the expenses of user internet bundles, because number of MBs to be charged will be smaller.

The uplink and downlink theoretical channel speed obtained were 7.67 Mbps and 28.13 Mbps respectively. The 64 Quadrature Amplitude Modulation (QAM) modulations with 2x2 MIMO was selected for downlink and 16 QAM for uplink. QAM was selected because it allows more bits per symbol, therefore more transmission bitrates. 2x2 MIMO will increase speed capacity, by using multiple antennas for transmission.

This study has shown that, the performance of HSPA+ release 9 in speed is higher than that of the prototype. Therefore, it is recommended to use multimedia authoring tools with a high degree of compression so that; the lower speed of the prototype can be more profitable.

This prototype for multimedia delivery over network has three benefits, high data transmission reliability due to adopted NTC Enhanced Viterbi, minimum network bandwidth utilization and satisfied uplink and downlink access speed.

This research also, suggests alternative studies of a similar nature but in the case of optical transmission. Optical transmission consists of high-speed transmission and allows multi-mode transmissions; therefore, analysis in multi-mode transmission of fiber can give impressive result.

ACKNOWLEDGMENT

Authors give thanks to Vijana Labs Co. Ltd, University of Iringa and University of Dodoma for their funds and resources, without the intense support from them this research publication would never have been carried out.

REFERENCES

[1] A. A. Ziden, M. A. Rahman “The effectiveness of web-based multimedia applications simulation in teaching and learning,” International journal of instruction, vol. 6, no.2, 2013.

[2] A. Kumar, et al., “Technology Evolution of 3GPP HSPA Family,” The Pacific Journal of Science and Technology, vol. 10, no. 2, 2009.

[3] A. Mohr, E. Riskin, R. Ladner, “Unequal loss protection: Graceful degradation over packet erasure channels through forward error correction,” IEEE Journal on Selected Areas in Communication, vol. 18, pp.819–828, 2000.

[4] Pradeep Kumar Shaga et al, “A New Approach of Forward Error Correction For Packet Loss Recovery”, International Journal of Computer Science and Mobile Computing, Vol.3 Issue.9, pg. 670-674, 2014.

[5] J., Praveen & HR, Vijay, “RS FEC Encoder in Optical fiber communication”, Conference: International Conference on Communication , VLSI and Signal Processing, Siddaganga Institute of Technology, Tumkur, 2013.

[6] Digdarsini, Durga & Mishra, Deepak & Mehta, Sanjay & Ram, TVS, “FPGA Implementation of FEC Encoder with BCH & LDPC Codes for DVB S2 System”, 6th International Conference on Signal Processing and Integrated Networks (SPIN), 78-81. 10.1109/SPIN.2019.8711664, 2019.

[7] Kang, Jing & An, Junshe & Wang, Bingbing, “An Efficient FEC Encoder Core for VCM LEO Satellite-Ground Communications”, IEEE Access, PP. 1-1. 10.1109/ACCESS.2020.3007923, 2020.

[8] Akkidas, Davidrichesemmanuel, “VITERBI ALGORITHM”, Journal of Experimental Algorithmics, 2015.

[9] Gottinger, Hans-Werner, “Networks, Competition, Innovation and Industrial Growth”, NovaScience Publishers, 2016.

[10] Vipul Mann, Deepak Maurya, Arun K. Tangirala, and Shankar Narasimhan, “Optimal Filtering and Residual Analysis in Errors-in-Variables Model Identification”, Industrial & Engineering Chemistry Research, 59 (5), 1953-1965, 10.1021/acs.iecr.9b04561, 2020.

[11] Xu, Jiakang & Weitnauer, Mary, “Practical models for interference cancellation residual error in transmission-only networks”, 2019 IEEE Wireless Communications and Networking Conference Workshop (WCNCW), 1-5. 10.1109/WCNCW.2019.8902661, 2019.

[12] Hassan, Kilavo & Kisangiri, Michael & Mrutu, Salehe, “Design of Soft VITERBI Algorithm Decoder Enhanced with Non-Transmittable Codewords for Storage Media”, International Journal of Computer Science, Engineering and Applications, 07. 01-11. 10.5121/ijcsea.2017.7101, 2017.

[13] Chowdhuri et al., “Recent research on Multiple Input Multiple Output (MIMO) based mobile ad hoc network”, International Journal of Service Science, Management, Engineering, and Tech., vol. 3, no. 5, pp. 54-65, 2014.

[14] F. David, "LTE Broadband and Public Safety," Tech report, LTE-Broadband and Public Safety Primer, 2011.

[15] H. Holmaand, A. Toskala, WCDMA for UMTS: HSPA Evolution and LTE, 5th ed., Wiley, West Sussex, UK, 2007.

[16] HSPA+ Advanced – Taking HSPA+ to the Next Level, QUALCOMM Inc., 2012.

[17] J. Vieron, T. Turletti, K. Salamatian, C. Guillemot, "Source and channel adaptive rate control for multicast layered video transmission based on a clustering algorithm," Eurasip journal on applied signal processing, vol.2, pp.158–175, 2003.

[18] M. Al-rousan, and A. Nawasrah, "Adaptive FEC Technique for Multimedia Applications Over the Internet," Journal of emerging technologies in web intelligence, vol. 4, no. 2, 2012.

[19] S. I. Mrutu, A. Sam, N. H. Mvungi, "Assessment of Non -Transmittable Codewords Enhancement to Viterbi Algorithm Decoding," International journal of computer science and information security, vol. 12, no. 9, 2014a.

[20] S. I. Mrutu, A. Sam, N. H. Mvungi, "Forward error correction convolutional codes for RTA's' networks: an overview," I. j. computer network and information security, vol. 7, pp.19-27, 2014b.

[21] S. I. Mrutu, A. Sam, N. H. Mvungi, "Trellis analysis of transmission burst errors in Viterbi decoding," International journal of computer science and information security, vol. 12, no. 8, 2014c.

[22] Wikipedia (2020a) Boyle's Law. [Online]. Available: https://en.wikipedia.org/wiki/Boyle%27s_law

[23] Wikipedia (2020b) Coding theory. [Online]. Available: https://en.wikipedia.org/wiki/Coding_theory

[24] Wikipedia (2020c) Multimedia. [Online]. Available: https://en.wikipedia.org/wiki/multimedia

[25] Wikipedia (2020d) Quadrature Amplitude Modulation. [Online]. Available: https://en.wikipedia.org/wiki/Quadrature_amplitude_modulation

[26] Y. Polyanskiy, H.V. Poor, and S. Verd´u, "Channel coding rate in the finite block length regime," in IEEE Trans. Inform. Theory, 2010.

[27] Ohm, Jens, "Transmission and Storage of Multimedia Data," Multimedia Signal Coding and Transmission, 10.1007/978-3-662-46691-9_9, 2015.

[28] Vasundra, S. & Venkatesh, D., "CLASDN- An Extension in Networking for Efficient Multimedia Data Transmission," International Journal of Computer Sciences and Engineering, 6. 83-88. 10.26438/ijcse/v6i11.8388, 2018.

[29] Schulist, Matthias & Hoidis, J & Garavaglia, A. HSPA+ MIMO Performance in Practice Practice, 2020.

[30] Holma, Harri, Karri Ranta-Aho, and Antti Toskala. "HSPA Multicarrier Evolution" , WCDMA for UMTS HSPA Evolution and LTE, 2010.

[31] S. Zhou, G.B. Giannakis. "How Accurate Channel Prediction Needs to be for TransmitBeamforming With Adaptive Modulation Over Rayleigh MIMO Channels?" , IEEE Transactions on Wireless Communications, 2004.

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